Communicating key indicators for sea level

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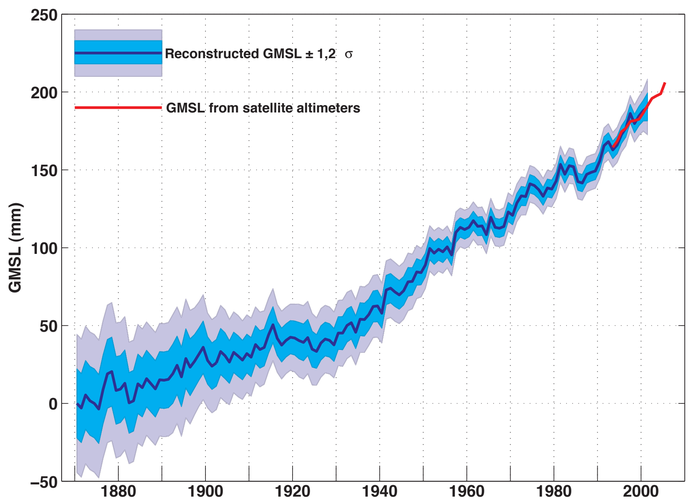
Introduction

Sea level is a key indicator of the state of the ocean as part of the climate system and sea-level rise is one of the most significant climate-change impacts. Despite this, there is no regular and systematic reporting of sea-level indicators in publications like the annual WMO Statement on the Status of the Global Climate. We advocate that the sea-level community (in consultation with the broader climate community) should agree on a number of key indicators that are reported on in a regular and systematic way. Several suggestions are outlined below.

We also advocate that regional sea-level predictions, for example as related to the El Niño-Southern Oscillation, should become part of regular climate predictions.

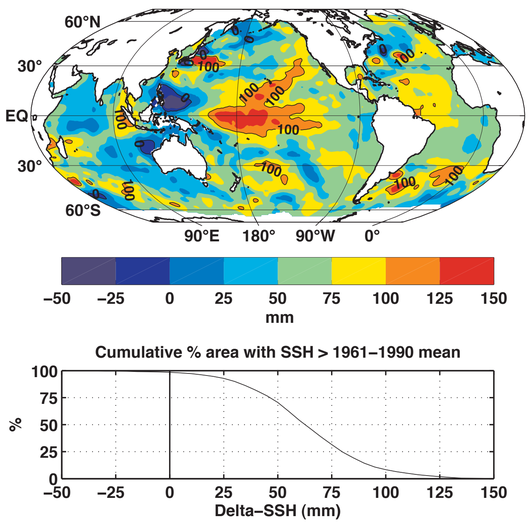
Global averaged sea level



Global-averaged sea level for 1870 to 2005: reconstruction from Church and White (2006) for 1870 to 2001, TOPEX/Poseidon and Jason-1 satellite altimeters for 1993 to 2005. All are yearly averages, with no inverse barometer correction.

Sea level rose by ~160mm through the 20th century. Global averaged sea level in 2005 was about 50mm higher than it was in 1990. Since the availability of high quality satellite altimeter data in 1993, sea level has risen by 42mm at an average rate of about 3.2mm yr^{-1}.

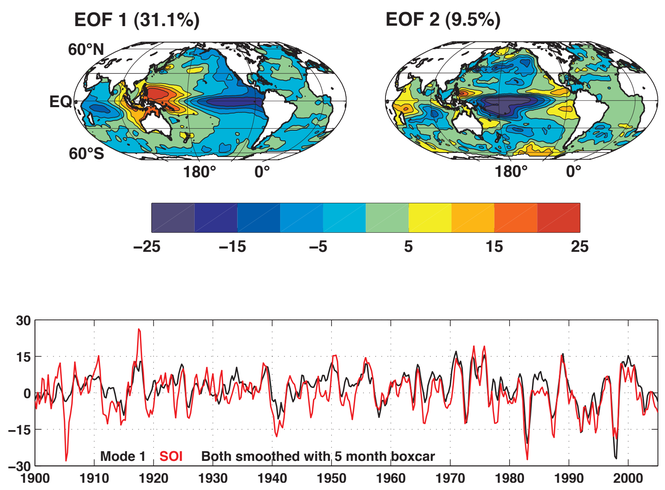
The regional distribution of sea level in 2004



Regional distribution of yearly mean sea level in 2004 with respect to the 1961-1990 mean (derived from the reconstructed sea level fields of Church *et al.*, 2004).

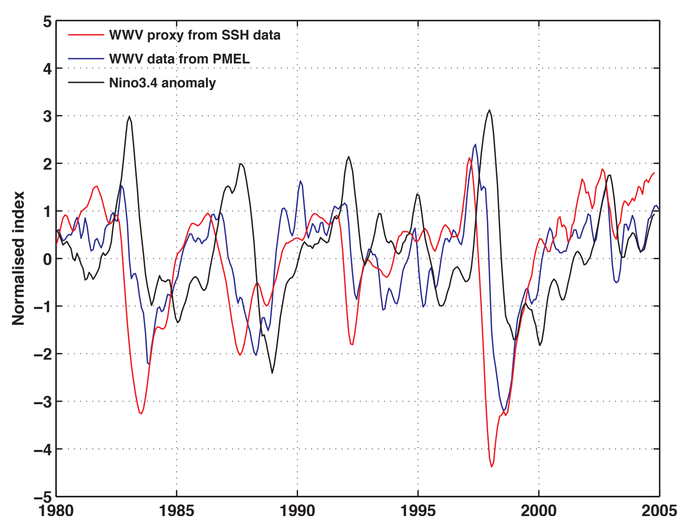
As well as the inexorable rise in sea level associated with climate change, there is also interannual variability in sea level. Sea level anomalies in 2004 compared with the average over the period 1961 to 1990 show large positive sea level anomalies in the central equatorial Pacific.

Sea-level indicators of the El Niño-Southern Oscillation



EOFs 1 and 2 from the TOPEX/Poseidon and Jason-1 satellite altimeter data (top) and comparison of the time series of SOI with the amplitude of EOF mode 1. The correlation between the two time series is 0.77. The percentage of variance explained by the EOF modes is also shown.

The largest interannual variability in sea level is associated with the El Niño-Southern Oscillation. Strong El Niño events lead to changes in sea level of tens of centimetres over much of the tropical Pacific, as well as other areas (*e.g.* off western North and South America and western Australia). These changes potentially contribute substantially to storm and surge damage.



Warm Water Volume (WWV) from PMEL, a proxy for WWV calculated from sea-surface height data and the Nino3.4 index (all normalised). Falls in the SSH-based WWV index lead falls in the PMEL WWV index which in turn lead the occurrences of warm SST anomalies (El Niño events).

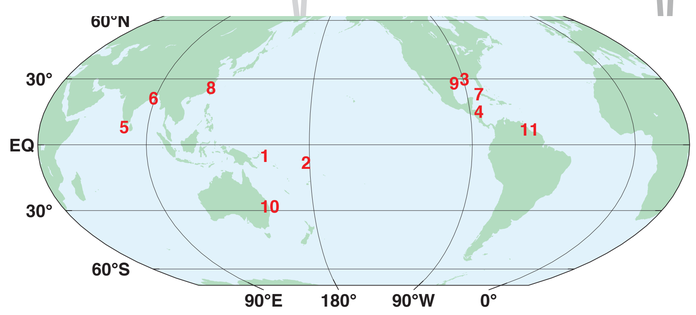
Indices calculated from sea-surface height data should, in principle, be better than indices calculated from surface temperatures as they are correlated with heat content, rather than surface temperature. This type of work is in its early stages, but shows promise.

Extreme events

Extremes of high sea level have increased over the 20th century, partly due to the rise in mean sea level. A useful indicator (not plotted here) is the difference between the 99-percentile annual sea-level extreme for the previous year and the average of this annual value over a control period (*e.g.* 1961 to 1990).

Poster design by Louise Bell, CSIRO Marine and Atmospheric Research

2005 sea-level impacts in review



Map of sea level events in 2005.

During 2005, extreme sea level events had major impacts:

1. Carteret Islands (Papua New Guinea) decision made to abandon them as they are becoming uninhabitable.
2. Tuvalu, Pacific Ocean: extensive flooding
3. New Orleans, USA: flooding associated with Hurricane Katrina, deadliest hurricane to hit the US since 1928. 1,200 deaths, 160,000 homes unsalvageable.
4. Nicaragua, Honduras: Flooding causing 20,000 people to be evacuated. Hurricane Beta.
5. Southern India. Coastal flooding causes loss of life, evacuation.
6. West Bengal. Heavy rains lead to 3,000 coastal villages inundated. 60,000 huts washed away.
7. Gulf of Mexico. Hurricane Wilma. 700,000 evacuated. Losses $2-$9 billion. Storm surge inundates 40 per cent of Key West, causes flooding in Havana.
8. China: Typhoon Longwang. 730,000 people evacuated ahead of storm from coastal areas. 5,400 homes destroyed.
9. Gulf of Mexico. Hurricane Rita storm surge flooding of the Gulf Coast. 2.8 million people evacuated from Houston and surrounding areas.
10. NSW, Qld, Australia. Worst floods in 30 years on Gold Coast.
11. Guyana. Four times average rainfall. Below sea level parts of George Town flooded. 375,000 people in shelters. 1,400 sq kilometres of coastal areas flooded.

Source: Dartmouth Flood Observatory

Conclusion

We advocate that the sea-level community (in consultation with the broader climate community) should agree on a number of key sea-level indicators that are reported on in a regular and systematic way in publications like the annual WMO Statement on the Status of the Global Climate and that regional sea-level predictions should become part of regular climate predictions.

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References

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